

## MODEL 3

# Gate model

## Access granted?



### KEY QUESTIONS:

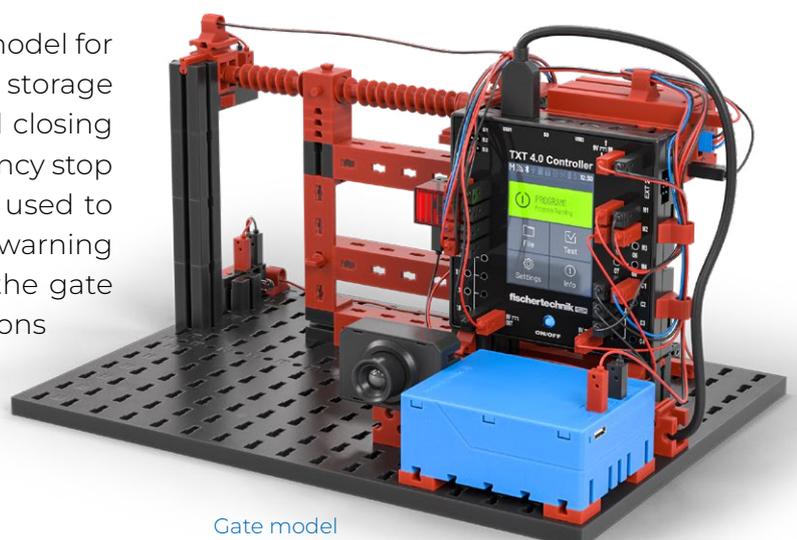
- How can end stops, interruptions, and distances be measured with sensors? (*Communication and information*)
- Which sensors can be used to meaningfully monitor and control gate operation? (*Collaboration*)
- Under what conditions should the system prioritize user protection over function? (*Critical thinking*)
- What must be considered so that the sensors can be used for different application scenarios and the system functions as robustly as possible? (*Creativity*)

### THE TEACHING CONCEPT AT A GLANCE

Grade level:	11–13
Time required:	2 double lessons (expandable up to 8 DL)
Degree of difficulty:	Model  Programming 
Model type:	Gate model for access control

### MODEL DESCRIPTION / TASK

The students plan and implement a gate model for sensor-based access control of a fictitious storage room. Starting from a simple opening and closing of the gate model controlled by an emergency stop switch, in a second step end switches are used to protect the mechanics, and in a third step warning LEDs are used to visualize the activity of the gate drive. A simple graphic display of the buttons *Open*, *Close*, and *Emergency Stop* is to be programmed on the display of the TXT 4.0 controller and put into operation.



Gate model

To avoid human error in monitoring the closing process and the associated pressing of the “Emergency Stop” button, closing control is to be automated by a light barrier that detects possible obstructions when the gate model closes and automatically triggers an emergency stop. At the same time, an optical signal in the form of permanently lit red LEDs indicates the stop of the closing process. Releasing the gate to close again should only be possible when there is no longer any obstruction in the gate and the “Open” button on the display of the TXT 4.0 controller has been pressed. Compared to the first solution with end switches, this automatic safety circuit represents a significant advancement in the development of automation of the gate model.

In the next step, automatic opening of the gate upon the approach of a person from the inside should be made possible through the use of an ultrasonic sensor. It is assumed that the legality of the desire to open has already been ensured when entering the storage room. If a person or a vehicle approaches the gate from the inside up to 20 cm, the gate should automatically initiate the opening process. Again, the LEDs should blink during the movement of the gate. Access to the storage area from outside should be restricted through the integration of color recognition using the USB camera. If a green object approaches, the gate should open automatically; with any other color, it should either remain locked or close.

An extended access control should be implemented via programming of a simple code lock. For this purpose, 7 buttons are placed on the display of the TXT 4.0 controller. Six of them are used to enter the code, and another to transmit the code and initiate the opening process if the code entry was correct. The code lock is a simple one, where the order of entries or multiple entries are not taken into account. It should only check whether keys have been pressed. However, it is left up to the students to program their own more complex code locks to protect the storage room.



## ○ EVERYDAY RELEVANCE

Embedding the topic in a realistic application context has high motivational value. Integration of the topic into preprofessional orientation could take place with regard to mechatronics or IT-related occupational

fields. Here, automated opening and closing is used in many areas. Automatic opening of doors or roller shutters is used not only in industry but also increasingly in the home environment.

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**SUBJECT REFERENCE**

<b>Information technology:</b>	Advanced programming, conditional loops, functions, coding, graphic displays
<b>Physics:</b>	Light barrier, distance measurement with ultrasonic sensor
<b>Technology:</b>	Stable construction, control of actuators, reading sensors, construction technology
<b>Mathematics:</b>	Calculation of terms

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**LESSON PLAN**
**Introductory phase**


Classroom discussion

- Announce the topic.
- Ask about the essential requirements for the automatic opening or closing of a gate or door model.
- Ask about scenarios in which automatically opening and closing gate/door systems are used.
- Discuss possible applications of the scenarios collected (e.g. garage door, yard gate, access gate, sliding door, roller shutter).
- Determine requirements for the experimental setup.



Support, if necessary

- Show sensors, actuators and components from the assembly kit, use presentation media if necessary.

**Planning Phase**


Classroom discussion

- The procedure for building the model and the target function are developed jointly.
- The work steps in the app are specified or discussed.



Partner or individual work

- The students familiarize themselves with the app and load the corresponding task.
- The students define meaningful functions of the control with the TXT 4.0 controller.
- The students use the app to create the requirements list for the gate model to be built.



**Optional:**  
Partner or  
group work

- The students sketch possible setups of the gate model themselves and construct it freely.
- The students discuss the results in the group and choose a design.

## Construction Phase



Partner or  
individual  
work

- The students use the app to build the gate model. The app guides them through the program in short steps.

## Programming Phase



Partner or  
individual  
work

- The students write the programs for the control tasks to be carried out with the experimental setup. The app guides them step by step through the programming task.
- The app offers assistance.
- The program is transferred to the TXT 4.0 controller after each differentiation step.

## Experimentation and Test Phase



Partner or  
group work

- The experimental setup is put into operation.
- Possible malfunctions in the functional sequence must be found and eliminated.
- Troubleshooting is possible with suggestions in the app.
- Possible optimizations of the hardware and the programming can be carried out.

## Final Phase



**Optional:**  
Presentation  
and allocation  
of differen-  
tiation

- Students eligible for differentiation may be addressed by the teacher if necessary. Here, the option of programming an extended code lock is presented.



Discussion in  
plenary

- Project debriefing in class.
- Clarification of future possible applications in everyday life

## METHODOLOGICAL AND INSTRUCTIVE TIPS

### Differentiation options

Depending on the duration of the lesson series and the abilities of the students:

- the introductory scenario of opening and closing of the gate model without end switches and with manual monitoring may be omitted,
- the experimental setup can be changed and sensors installed/used in other places,
- the code lock can be improved,
- a competition “Who cracks the code?” for the best programming of a code lock can follow (conversion of the gate model into a safe that must either be cracked or protected).
- Further application scenarios can be formulated by the students and implemented along with setup and programming.

### Motivational aspects

The topic of automatic control of movement is familiar to all students from everyday life. In many households, automatically opening roller shutters, awnings, or garage doors, along with many other smart applications, have long been part of everyday life. Electronic, code-based door locks are increasingly used for building access control.

## PROGRAMMING SKILLS

- Program start
- Integration of sensors
- Integration of actuators
- Integration of the TXT 4.0 controller display
- Integration of inputs via a touch display
- Camera configuration
- Infinite loop **repeat forever**
- Condition **if – do**
- Command **wait**
- Command **wait until**
- Working with subprograms
- Use of events and threads

## ADDITIONAL MATERIALS

### Optional download:

- Circuit diagram
- Building instructions

- If available, materials for programming code locks can be used.
- Use drawing media (paper, whiteboard, or projection screen).

## FUNCTIONS OF THE MODEL AND THEIR TECHNICAL SOLUTIONS

Function of the sensors/actuators	Technical solution
Red LEDs	Control LEDs during gate movement
Light barrier interruption	Prevent gate movement
Ultrasonic sensor	Proximity detection
<b>Differentiation</b>	Design of variously complex gate protections or gate controls (code lock, combination of sensor inputs)

## MATERIAL LIST

Sensors	Function
1 On/Off push button on the TXT 4.0 controller	<ol style="list-style-type: none"> <li>1. Switch on the barrier control</li> <li>2. Emergency stop of the barrier</li> </ol>
1 ultrasonic sensor	Proximity detection
1 USB camera	Color recognition
1 photo transistor	Light barrier interruption detection, receiver
2 mini push buttons	End switch for gate control

Actuators	Function
1 TXT 4.0 controller display	Display
2 LEDs (2 × red)	Warning
1 encoder motor	Movement of the gate
1 LED (white)	Illumination of light barrier sensor